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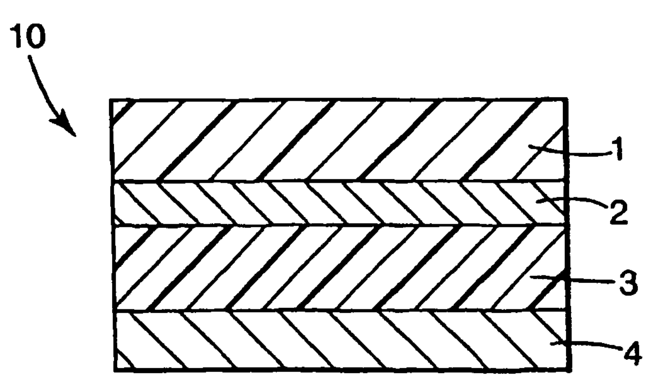
(54) Title: CONSTRAINT-TYPE VISCOELASTIC DAMPERS



(57) Abstract: To solve a problem of head failure caused by charging of a polyimide film in a constraint-type viscoelastic damper using the polyimide film as a constraint material. A constraint-type viscoelastic damper comprising a constraint member (1) made of a polyimide resin and a viscoelastic member (3) in combination, characterized in that the constraint member has an electrically-conductive paint layer (2) provided at least one surface of the member.

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CONSTRAINT-TYPE VISCOELASTIC DAMPERS

Detailed Description of the Invention

The present invention relates to a damping apparatus and, more particularly, to a damping apparatus for applying to a head suspension in a disc device such as hard disc drive (HDD), magneto-optic disc drive thereby to damp vibration caused by rotation of the disc, driving of the head or the like. The damping apparatus of the present invention particularly relates to a constraint-type viscoelastic damper.

Prior Art

To damp vibration produced on driving of various driving apparatuses, a viscoelastic damper has conventionally been used. The viscoelastic damper is capable of exerting a vibration damping effect by converting a vibration energy into a heat energy. The viscoelastic damper is roughly classified into a constraint-type and a non-constraint-type and used properly for various purposes depending on each feature. Although the constraint-type viscoelastic damper has various types, any viscoelastic damper has a structure using a constraint member in combination with a viscoelastic member. The constraint-type viscoelastic damper can exhibit a larger damping effect than that of the non-constraint-type viscoelastic damper because of utilization of slip deformation of the viscoelastic member and, therefore, it can be widely used.

As is described in Japanese Examined Patent Publication (Kokoku) No. 4-8868, the constraint-type viscoelastic damper used particularly in HDD has such a configuration that a viscoelastic material such as adhesive, rubber or the like is laminated on a metal plate made of stainless steel as a constraint material and a release liner for prevention of adhesion is laminated thereof. However, this kind of a damper is superior in damping characteristics because the metal plate is used as the constraint material. On the contrary, it has such problems that burr peculiar to the metal occurs at the worked end portion and it is difficult to form into a fine shape and that lightening of the damper can not be attained because of large weight of the constraint material. It has becomes impossible for the constraint material made of metal to sufficiently meet recent demands on the head suspension of the disc device, e.g. low rigidity and miniaturization.

It is a damping material to be applied to the head suspension of the disc device as disclosed in Japanese Unexamined Patent Publication (Kokai) No. 9-91909 that has been developed to solve the above problems caused by use of the constraint material made of metal. This damping material is characterized by laminating a constraint material made of a polyimide film having an elastic modulus of not less than 500 kg/mm^2 and a viscoelastic material made of an acrylic adhesive each other. That is, this damping material is characterized by using a special polyimide film having the same damping characteristics as those of a constraint material made of metal, which is lightweight and attains low material cost and hardly causes burr in a fine punching operation, in place of the metal plate having various problems. The viscoelastic material made of the acrylic adhesive is previously covered with a release liner for prevention of adhesion.

However, the damping material using the polyimide film as the constraint material has the following problem. That is, when the damping material is applying to the head suspension, static electricity is caused by the operation of separating the release liner from the viscoelastic material, thereby causing failure of the head itself.

Since the polyimide film is usually inferior in adhesion to the viscoelastic material, failure of the member is liable to occur because of poor cutting at the end portion of the damping material on the punching operation of the damping material.

Problems to be Solved by the Invention

The present invention has been accomplished to solve the above problems of a conventional damping material using the polyimide film as the constraint material.

Accordingly, an object of the present invention is to provide an improved constraint-type viscoelastic damper capable of clearing the problem of charging of the polyimide film thereby making it possible to solve the problem of head failure in a constraint-type viscoelastic damper using the polyimide film as the constraint material, which has the same damping characteristics as those of a constraint material made of metal and is lightweight, and which attains low material cost and hardly causes burr in a fine punching operation.

Another object of the present invention is to provide an improved constraint-type viscoelastic damper, which can improve the adhesion of the polyimide film to the

viscoelastic material and clear the problem of failure of the damper end portion on the punching operation.

Means for Solving the Problem

The present inventors have now obtained such a knowledge that use of the constraint material in combination of a conductive paint layer is effective for prevention of charging in a constraint-type viscoelastic damper using the polyimide film as the constraint material, thus completing the present invention.

That is, according to the present invention, there is provided a constraint-type viscoelastic damper comprising a constraint member made of a polyimide resin and a viscoelastic member in combination, characterized in that the constraint member has an electrically-conductive paint layer provided at least one surface of the member.

In the viscoelastic damper according to the present invention, it is effective to contain a urethane resin in a binder of the paint layer so as to improve the adhesion between the constraint member made of the polyimide resin and the viscoelastic member.

Embodiments for Carrying Out the Invention

The constraint-type viscoelastic damper according to the present invention comprises a constraint member made of a polyimide resin and a viscoelastic member in combination, as described above. Accordingly, the combination of the constraint member and viscoelastic member can vary widely within the scope of the present invention. The viscoelastic damper according to the present invention can be formed as an integrated material obtained by laminating the constraint member made of the polyimide resin and the viscoelastic member each other, as is usually conducted in this technical field.

As described above, the constraint member is made of the polyimide resin. Because the polyimide resin has the same damping characteristics as those of a constraint material made of metal, and is lightweight and attains low material cost and, furthermore, the polyimide resin is easily formed into a fine shape by punching and hardly causes burr. The constraint member made of the polyimide resin is preferably used in the form of a film, and its elastic modulus is preferably at least 500 kg/mm^2 when measured in accordance with Japanese Industrial Standard (JIS) K-7127. Because a normal polyimide film having an elastic modulus of not more than about 300 kg/mm^2 is inferior in damping

characteristics and is not suited for practical use. Examples of the polyimide film, which is useful as the constraint member, include polyimide film commercially available from Ube Kosan Co, under the trade name of "Yupirex-S" having an elastic modulus of 650 kg/mm^2.

The thickness of such a film-like constraint member is not specifically limited and can vary widely depending on the desired effect, but is usually within a range from 10 to 200 μm, and more preferably from 15 to 180 μm,

The viscoelastic member used in combination with the above constraint member is used mainly for the purpose of exhibiting a damping effect, and can be formed of a natural or synthetic viscoelastic polymer material used generally in the viscoelastic damper. Accordingly, proper viscoelastic polymer material includes, for example, natural and synthetic rubbers (e.g. butyl rubber, isoprene rubber, butadiene rubber, chloroprene rubber, butadiene-acrylonitrile rubber, polynorbornene rubber, silicone rubber, silicone gel, etc.), polyether urethane, copolymer of alkyl acrylate and one or more acrylic monomer (e.g. acrylic acid, acrylamide, etc.), ethylene-vinyl acetate copolymer, ethylene-ethyl acrylate copolymer, ethylene-propylene-diene copolymer, and chlorosulfonated polyethylene. As such a viscoelastic polymer material, for example, there can be advantageously used "VEMISD 112" and "VEM type 110, 111, 112 or 113", which are commercially available from Sumitomo 3M Co.

Such a viscoelastic member is preferably used in the form of a film and its thickness can vary widely depending on the desired effect, but is preferably within a range from 10 to 100 μm, and more preferably from 15 to 90 μm.

In the constraint-type viscoelastic damper according to the present invention, it is essential that the constraint member has a conductive paint layer provided at least one surface of the member.

In the viscoelastic damper according to the present invention, the conductive paint layer is preferably provided on one surface of the constraint member so that the paint layer is laid between the constraint member and the viscoelastic member. Such a configuration of the conductive paint layer is as shown in Fig. 1. That is, a viscoelastic damper 10 is formed in such a configuration that a constraint member 1 made of a polyimide film and a viscoelastic member 3 are laminated each other, while a conductive paint layer is laid between the constraint member 1 and viscoelastic member 3. A release liner 4 is provided

on the opposite side of the constraint member 1 to the viscoelastic member 3 so as to protect the viscoelastic member 3. If necessary, an additional conductive paint layer (not shown) may also be provided on the other surface of the constraint member.

If necessary, as shown in Fig. 2, the electrically-conductive paint layer 2 may be provided on the opposite side of the constraint member 1 to the viscoelastic member 3 as a modification of the construction shown in Fig. 1. With such a construction, it is impossible to obtain the effect obtained when the conductive paint layer 2 is laid the constraint member 1 and viscoelastic member 3, but the effect of the conductive paint layer 2 itself can be sufficiently obtained.

Accordingly, it is effective for prevention of head failure.

The electrically-conductive paint layer used in the viscoelastic damper of the present invention preferably has a surface resistance smaller than a predetermined level so as to reduce the amount of charge of the polyimide film. The surface resistance, which is effective in the present invention, is preferably not more than 10^{12} Ω/□, more preferably from 10^{-3} to 10^{12} Ω/□, and most preferably from 10^{2} to 10^{8} Ω/□.

The conductive paint layer preferably contains a urethane resin as a principal component (binder resin). According to the present inventors, knowledge, the urethane paint layer can particularly contribute to an improvement in adhesion between the polyimide film and viscoelastic material and can inhibit failure of the viscoelastic material at the end portion of the damper on the punching operation. Although a polyester resin may also be used as the binder resin, this resin can not be advantageously used because its hardness makes it difficult to blend conductive particles and its adhesion with the polyimide to be used as the constraint member is also poor. Proper urethane resin in working of the invention includes, for example, "Ramic F" (trade name) manufactured by Dainichi Seika Co.

The amount of the urethane resin contained in the paint layer can vary widely, but is preferably within a range from 10 to 100% by weight, and more preferably from 50 to 100% by weight.

Furthermore, the conductive paint layer preferably contains the urethane resin as the principal component and contains conductive particles dispersed in the resin. Because the conductive particles make it easy to reduce the surface resistance of the paint layer and to control it to any desired value.

The conductive particles suited for dispersion in the paint layer are not specifically limited as far as the particles can impart conductivity to the paint layer in a predetermined level, but preferred examples thereof include carbon black, nickel powder, nickel-coated graphite powder, nickel-coated alumina powder, stainless steel powder, zinc powder and the like. Among them, carbon black is particularly preferred. The particle diameter of the conductive particles used herein can vary widely depending on ease of coating and thickness of the paint layer, but is usually within a range from 0.1 to 1 μm.

The amount of the conductive particles to be dispersed can vary widely depending on the desired results, but is preferably within a range from 5 to 60% by weight, and more preferably from 10 to 50% by weight. At present, the paint containing the conductive particles in the state of being dispersed therein is, for example, commercially available from Dainichi Seika Co. under the trade name of "Seika Seven" as carbon-containing conductive paint, and this paint can also be used in working of the present invention.

When it is desired to attain both of the antistatic effect and improvement in adhesion on working of the present invention, two kinds of paints described above, i.e. "Ramic F" and "Seika Seven" manufactured by Dainichi Seika Co. are used in combination. Even if "Ramic F" is used alone, when the paint is black, the surface resistance can be reduced to about 10^{10} Ω/□ and slight antistatic effect can be obtained. If "Ramic F" and "Seika Seven" are used in combination, the surface resistance are further reduced to an order ranging from 10^4 to 10^{10} Ω/□ and larger antistatic effect can be obtained.

Furthermore, the thickness of the conductive paint layer can vary widely depending on the desired effect, but is preferably within a range from 0.5 to 8 μm, and more preferably from 2 to 6 μm. When the thickness of the paint layer is smaller than 0.5 μm, not only sufficient antistatic effect can not be obtained but also an influence of the conductive particles makes it difficult to coat the resulting paint. On the other hand, even if it exceeds 8 μm, a further improvement in antistatic effect can not be expected.

In the viscoelastic damper of the present invention, the viscoelastic damper is preferably protected with a release liner immediately before use so as to cause an undesired binding on the adhesive surface. The release liner, which can be used herein, is one used generally in a conventional viscoelastic damper.

Examples

The present invention will be described below with reference to examples thereof,

Example 1

A polyimide film having a film thickness of 50 μm, which is commercially available from Ube Kosan Co, under the trade name of "Yupirex-S (product treated with GA), was prepared. Separately, carbon particles-containing conductive paint "Seika Seven CD727 (trade name)" and urethane paint "Ramic F220 Black (trade name)", both of which are commercially available from Dainichi Seika Co, were blended in a ratio of 3:1 and the resulting conductive paint was coated on a polyimide film in a thickness of about 3 to 5 μm, Then, a film-like viscoelastic material commercially available from Sumitomo 3M Co. under the trade name of "VEMISD 112" was laminated on the formed conductive paint layer. Finally, an original liner was removed from the laminated viscoelastic material and a non-silicone liner commercially available from Sumitomo 3M Co. under the trade name of "Scotchpak 1022" was applied in place of it. The resulting laminate was punched by using a high-speed press to make a constraint-type viscoelastic damper having a length of 2 mm and a width of 2 mm. In the end portion of the resulting damper, no burr occurred.

In the constraint-type viscoelastic damper thus obtained,

(1) surface resistance of the polyimide film before the viscoelastic material was laminated thereon,

(2) amount of charge on the surface of the viscoelastic material on peeling of the liner from the damper, and

(3) adhesion between the polyimide film and the viscoelastic material were measured. The surface resistance of the polyimide film was measured by using a high resistance-resistivity meter "Hiresta IP MCP: HT250" manufactured by Mitsubishi Yuka Co. The amount of charge on the surface of the viscoelastic material was measured after applying a double-coated tape with a PET substrate to an acrylic plate, applying a PET liner thereon, applying a test damper having a width of 25 mm thereon and peeling them from the acrylic plate at peel rate of 300 mm/minute. A measuring device used was 3M Static Sensor 709 (trade name) commercially available from Sumitomo 3M Co. The adhesion between the polyimide film and viscoelastic material was measured after

applying a test damper having a width of 25 mm to an anodized aluminum oxide foil and subjecting to a T-peel test at a peel rate of 10 mm/minute. The following results were obtained.

Surface resistance of the polyimide film: 10^5 Ω/□

Amount of charge on the surface of the viscoelastic material: 600 V

Adhesion between the polyimide film and viscoelastic material: 1600 g

(Cohesive failure of the viscoelastic material occurred)

Furthermore, the viscoelastic damper of this example was evaluated by the following three items, i.e. (1) antistatic effect, (2) adhesion and (3) general evaluation on the basis of the above measurement results. Each item was evaluated by the following criteria (four levels).

◎ : Sufficiently satisfactory effect is obtained.

O : Satisfactory effective is obtained.

Δ : Ordinary effect is obtained.

× : Satisfactory effect is not obtained.

The evaluation results described in Table 1 below were obtained.

Example 2

The same procedure as in Example 1 was repeated, except that blend paint of the conductive paint and urethane paint (3:1) was coated in a thickness of about 1 μm in this example, as shown in Table 1 below. The evaluation results described in Table 1 below were obtained. The antistatic effect is slightly inferior to Example 1, but the resultant was suited to practical use.

Example 3

The same procedure as in Example 1 was repeated, except that only urethane paint "Ramic F220 Black" was coated in a thickness of about 5 μm in this example. The evaluation results described in Table 1 below were obtained. The resultant was suited to practical use, but is inferior in antistatic effect to Example 1.

Example 4

The same procedure as in Example 1 was repeated, except that only carbon particles-containing conductive paint "Seika Seven CD727" was coated in a thickness of about 5 μm in this example. The evaluation results described in Table 1 below were obtained. The resultant was suited to practical use, but is inferior in adhesion to Example 1.

Example 5

The same procedure as in Example 1 was repeated, except that 3:1 blend paint was prepared by reducing the amount of carbon particles-containing conductive paint "Seika Seven CD727" to 10% and was coated in a thickness of about 5 μm in this example. The evaluation results described in Table 1 below were obtained. The resultant was suited to practical use, but is inferior in both of antistatic effect and adhesion to Example 1.

Example 6 (Comparative Example)

The same procedure as in Example 1 was repeated, except that the conductive paint layer laid between the polyimide film and the viscoelastic material was omitted for comparison in this example. The following measurement results were obtained,

Surface resistance of the polyimide film: 10^{12} Ω/□ or higher

Amount of charge on the surface of the viscoelastic material: 7000 V

Adhesion between the polyimide film and viscoelastic material: 1100 g

(peeling off of the interface of the polyimide film)

Furthermore, the viscoelastic damper of this example was subjected to the evaluation test about three items in the same manner as in Example 1. The evaluation results described in Table 1 below were obtained.

Example 7 (Comparative Example)

The same procedure as in Example 1 was repeated, except that blend paint of the conductive paint and urethane paint (3:1) was coated in a thickness of about 0.3 μm for comparison in this example, as shown in Table 1 below. The evaluation results described in Table 1 below were obtained. In this example, a uniform painted surface could not be obtained because of too small thickness of the paint layer.

Accordingly, uneven antistatic effect was obtained.

Example 8 (Comparative Example)

The same procedure as in Example 1 was repeated, except that 3:1 blend paint was prepared by reducing the amount of carbon particles-containing conductive paint "Seika Seven CD727" to 3% and was coated in a thickness of about 5 μm for comparison in this example. The evaluation results described in Table 1 below were obtained. In this example, the antistatic effect was insufficient because of too small amount of carbon particles.

Example 9 (Comparative Example)

The same procedure as in Example 1 was repeated, except that 3:1 blend paint was prepared by reducing the amount of carbon particles-containing conductive paint "Seika Seven CD727" to 75% and was coated in a thickness of about 5 μm for comparison in this example. The evaluation results described in Table 1 below were obtained. In this example, the paint layer became brittle and crack occurred because of too large amount of carbon particles.

Example 10 (Comparative Example)

The same procedure as in Example 1 was repeated, except that only black ink using a polyester resin as a binder resin, manufactured by Toyo Ink Co under the trade name of "LPE Black", was coated in a thickness of about 5 μm for comparison in this example. The evaluation results described in Table 1 below were obtained. In this example, small antistatic effect was obtained, but is slightly inferior to the case where a urethane resin containing a large amount of carbon is used. When using a polyester binder resin, the viscosity tends to increase with the increase of the amount of carbon and, therefore, the amount of carbon can not be increased in the amount larger than that used in this example. The adhesion was also inferior.

Table 1

Example No.	Amount of Urethane resin	Amount of Carbon particles	Thickness of paint layer	Antistatic effect	Adhesion	General evaluation
1	60%	40%	5 μm	◎	◎	◎
2	60%	40%	1 μm	○	◎	○
3	60%	40%	5 μm	Δ	◎	○
4	60%	40%	5 μm	◎	○	○
5	90%	10%	5 μm	○	Δ	○
6 (Comp. Example)	-	-	-	×	×	×
7 (Comp. Example)	60%	40%	0.3 μm	×	○	×
8 (Comp Example)	97%	3%	5 μm	×	○	×
9 (Comp Example)	25%	75%	5 μm	-	-	×
10 (Comp Example)	0% Polyester	25%	5 μm	Δ	×	×

Effect of the Invention

As described above, according to the present invention, there can be provided a constraint-type viscoelastic damper having the same damping characteristics as those of a constraint material made of metal, which is lightweight and attains low material cost and hardly causes burr in a fine punching operation, by using a polyimide film as a constraint material. According to the present invention, by using the constraint material made of the polyimide film in combination with a conductive paint layer, the problem of charging of the polyimide film can be cleared and the problem of head failure can be solved. Furthermore, according to the present invention, since the adhesion of the polyimide film to a viscoelastic material can be improved, the problem of failure of the damper end portion on a punching operation can also be solved.

Brief Description of the Drawings

Fig. 1 is a sectional view showing one preferred embodiment of the constraint-type viscoelastic damper according to the present invention. [Fig. 2]

Fig. 2 is a sectional view showing another preferred embodiment of the constraint-type viscoelastic damper according to the present invention.

What is claimed is:

1. A constraint-type viscoelastic damper comprising a constraint member made of a polyimide resin and a viscoelastic member in combination, wherein the contraint member has a first surface facing the viscoelastic member and a second surface opposite the first surface, characterized in that the constraint member has an electrically-conductive paint layer provided on at least one of the first and second surfaces of the constraint member.

2. The constraint-type viscoelastic damper according to claim 1, wherein the paint layer is between the first surface of the constraint member and the viscoelastic member.

3. The constraint-type viscoelastic damper according to claim 1, wherein the paint layer is provided on the second surface of the constraint member.

4. The constraint-type viscoelastic damper according to any of claims 1 - 3, wherein the paint layer has a surface resistance of not more than 10^{12} Ω/□.

5. The constraint-type viscoelastic damper according to any of claims 1 - 4, wherein the paint layer comprises a urethane resin and conductive particles dispersed in the resin.

6. The constraint type viscoelastic damper according to claim 5, wherein the conductive particles are carbon black particles.

7. The constraint-type viscoelastic damper according to claim 5, wherein the paint layer contains the urethane resin in an amount within a range from 10 to 100% by weight.

8. The constraint-type viscoelastic damper according to any of claims 5 and 6, wherein the paint layer contains the conductive particles in an amount within a range from 5 to 60% by weight in the state of being dispersed.

9. The constraint-type viscoelastic damper according to any of claims 1 - 7, wherein the paint layer has a thickness of 0.5 to 8 μm.

10. The constraint-type viscoelastic damper according to claim 1, wherein the constraint member is in the form of a film and its thickness is from 10 to 200 μm.

11. The constraint-type viscoelastic damper according to claim 10, wherein the viscoelastic member is in the form of a film and its thickness is from 10 to 100 μm.

12. The constraint-type viscoelastic damper according to claim 1, wherein the voscoelastic member is made of at least one of butyl rubber, isoprene rubber, butadiene rubber, chloroprene rubber, butadiene-acrylonitrile rubber, plynorbornene rubber, silicone rubber, silicone gel, polyether urthane, copolymer of alkyl acrylate and acrylic acid or acrylamide, ethylene-vinyl acetate copolymer, ethylene-ethyl acrylate copolymer, ethylene-propylene-diene copolymer or chlorosulfonated polyethylene

13. The constraint-type viscoelastic damper according to claim 1, wherein the viscoelastic member is covered with a non-silicone release liner.

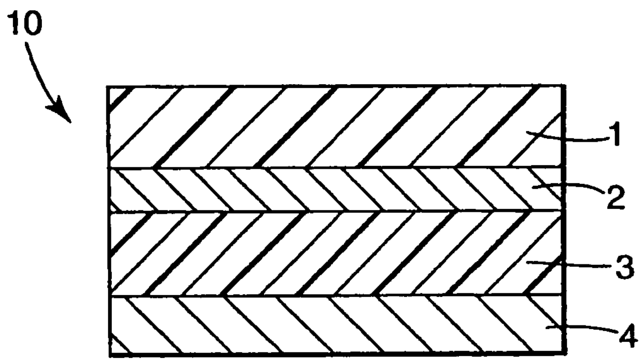

Fig. 1

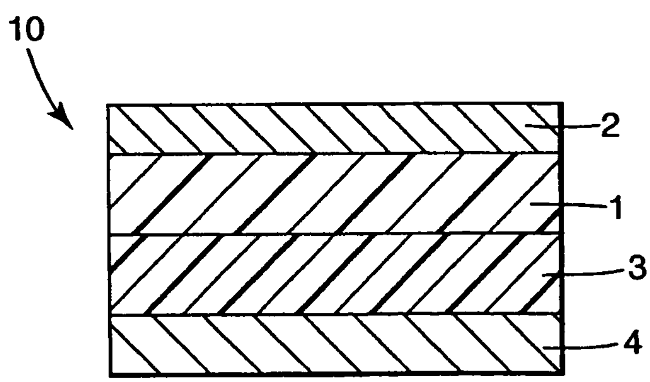

Fig. 2

INTERNATIONAL SEARCH REPORT

Interr ıal Application No
PCT/US 00/19966

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F16F9/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F16F B32B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 803 112 A (KAKIMOTO HIROFUMI ET AL) 7 February 1989 (1989-02-07) column 10, line 16-60; figures	1
A	WO 97 38237 A (MINNESOTA MINING & MFG) 16 October 1997 (1997-10-16) page 19, line 25 -page 20, line 22 page 35, line 1-23; figures	1
A	WO 96 04651 A (MINNESOTA MINING & MFG) 15 February 1996 (1996-02-15) page 8, line 32 -page 9, line 7 page 19, line 11-31; figures	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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Date of the actual completion of the international search	Date of mailing of the international search report
16 October 2000	24/10/2000

Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
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